Cost Efficiency, Technological Progress and Productivity Growth of Chinese Banking Pre and Post WTO Accession

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Abstract

During the last several years, China has taken substantial steps to reform its banking sector in line with its gradual integration with the global financial community, particularly after joining the World Trade Organization (WTO) in December 2001. This study examines the effect of recent banking reforms and WTO accession on the cost efficiency of the Chinese banking sector and the efficiency differentials across different bank ownership. We use a non-parametric approach to investigate the efficiency trend and productivity growth of banks between 1998 and 2006 prior to and after joining the WTO. We find that, on average, domestic banks outperform their foreign counterparts over the sample period in terms of overall and allocative efficiency, but they fall behind in terms of overall technical efficiency. The comparison of efficiency indices pre and post WTO accession reveals that the efficiency of domestic banks has declined post accession, while foreign banks have enjoyed an improvement in their cost efficiency post WTO accession. The findings further suggest that the total factor productivity of Chinese banks has weakened over the period under study. However, a pre and post analysis of WTO accession results shows that total factor productivity has increased for both domestic and foreign banks after China joined the WTO, equally owing to efficiency improvement and technological progress

JEL Codes: G1, G15, G2, G21

Key words: Banking cost efficiency, Ownership groups, WTO, Malmquist productivity, People's Republic of China

1. Introduction

The adoption of an "open-door" policy in 1978 followed by accession to the World Trade Organization (WTO) on December 11, 2001, and subsequent external trade liberalization allowed the Chinese economy to grow consistently in the past two decades. At the end of 2008, China's economy as measured by nominal Gross Domestic Product (GDP) was the third largest in the world after the United States and Japan. After factoring in the price differentials and measuring the purchasing power parity adjusted GDP, many economists believe that China's GDP is actually the second largest economy in the world behind the United States. It is expected that this growth momentum will continue at least for the next twenty years (Holz 2006). As of this writing, all signs of macroeconomic variables are pointing to further growth of the Chinese economy.

This phenomenal growth is due to many factors, among which are high domestic saving rates, an increase in the efficiency of production, large foreign direct investments, transfer of technology, and the availability of an inexpensive labor force. Without any doubt, the Chinese financial system has served well the economy in allocating economic resources to more productive uses. Although there are equity and bond markets in China, the major financiers for non-financial firms are banks and the current financial system is mostly dominated by the banking sector. Both equity and bond markets are indeed small relative to the size of the banking system[1].

The challenges faced by China's financial system, particularly its banking system,

[1] The dominant role of banking system in China is evident by looking at the flow of new funds into the economy. The share of banking sector loans as a percentage of total new sources of funds provided to non-financial enterprises is about 75 percent during the period of study, 1998-2006. The bond market (approximately USD 500 billion) is mostly dominated by Treasury bills and 1-10 years Treasury notes. The new funds raised in the equity market through Initial Public Offerings (IPOs), albeit increasing, is still small compared with loans made by banks and is mostly raised through IPO listings in Hong Kong rather than the two stock exchanges in mainland China- the Shanghai and Shenzhen exchanges.

are not different from other emerging markets. Specifically, the Chinese banking system suffers from the following symptoms: small capital and credit markets with limited number of market participants; lack of healthy competition in banking sector because of market domination by a few large banks; existence of adverse selection and moral hazard due to costly and asymmetrically distributed information; weak and ineffective accounting systems; absence of regulation and of solid protection of property rights, inadequate bankruptcy laws and tax system; and finally high level of non-performing loans (NPL) caused by the lack of credit quality evaluation, risk management, prudential investment, and corporate governance.

Existing research indicates that there is a positive relationship between the sustainability of economic growth and financial sector development in emerging economies[2]. In the past twenty years, China has introduced a series of banking reforms to increase the efficiency and viability of its banking sector, which dominates the financial system. This study investigates whether the efficiency and productivity of the banking sector in China has improved in recent years, especially after accession to the WTO in December 2001. We also examine the potential determinants of Chinese banking sector inefficiency. These issues are of major importance since China has agreed to open its financial system to full foreign competition as of December 11, 2006.

A limited number of studies have investigated the efficiency of the Chinese banking sector focusing mainly on differences in bank efficiency across ownership structures (see for example Lin and Zhang, 2009; Berger, Hasan, and Zhou, 2009; Shujie, Feng, and Willenbockel, 2007; Fu and Heffernan, 2005; Chen, Skully, and Brown, 2005;

[2] Among others, recent studies include Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2003), Beck, Demirguc-Kunt, and Maksimovic (2005), Jappelli, Pagano, and Bianco (2005).

and Kumbhakar and Wang, 2005). However, previous studies have employed data prior to 2004 at most, where the benefits from accession of China to the WTO have not likely materialized yet. Furthermore, foreign bank deregulation took place in the year 2003, and no prior research has examined the efficiency of domestic/foreign banks after foreigners were granted greater right of entry to the market. Our research first distinguishes itself from previous work by extending the sample coverage for a period of nine years between 1998 and 2006. Therefore, our study is more likely to better capture the impact of WTO accession and foreign bank deregulation on banking efficiency in China. We also present greater insight into Chinese banking efficiency by using a larger sample of 62 banks, compared to the previous literature where only a small number of banks is employed. Indeed, Chen, Skully, and Brown (2005) examine 43 banks; Berger, Hasan, and Zhou (2009) cover 38 banks; and Kumbhakar and Wang (2005) analyze 14 banks.

Second, the present paper differs from previous research in terms of methodology and scope employed. Each of Berger, Hasan, and Zhou (2009), Shujie, Feng, and Willenbockel (2007), Fu and Heffernan (2005), and Kumbhakar and Wang (2005) use stochastic frontier analysis to examine banking efficiency in China. We employ instead the non-parametric approach, similar to Chen, Skully, and Brown (2005). Our study is also different in scope by addressing issues not previously raised in the literature. Particularly, we analyze efficiency change and its components for banks before and after China joined the WTO, and perform a similar analysis with respect to productivity growth. Finally, we investigate the potential determinants of Chinese banking efficiency using Tobit regression models.

The rest of the paper is organized as follows. Section II provides a review of the

literature in the area of banking efficiency in China. Section III outlines the recent reforms of the Chinese banking sector. Section IV describes the data and methodology; section V discusses the empirical results; and section VI concludes the paper with a number of policy implications.

2. Review of Literature

There have been a growing number of studies in the past twenty years examining the efficiency of banks in different regions of the world[3]. We narrow our review of the present banking efficiency literature to emerging economies in Asia, and with more emphasis on China. The recent surge in empirical research shows a rising interest in the efficiency of banks in Japan (Fukuyama, 1995), Taiwan (Yeh, 1996), Thailand (Leightner and Lovell, 1998), Korea (Gilbert and Wilson, 1998), Singapore (Lim and Chu, 1998; Rezvanian and Mehdian, 2002), and India (Bhattacharyya, Lovell, and Sahay,1997; Bhattacharyya and Kumbhakar, 1997; Kumbhakar and Sarkar, 2003 and 2004; Ataullah Cockerill, and Hang, 2004; Ataullah and Hang, 2006; and Rezvanian, Rao, and Mehdian 2007).

In spite of the voluminous body of research on other Asian economies, studies on the Chinese banking sector in particular are limited. Some papers have used financial ratio analysis to examine profit and cost performance of Chinese banks as well as foreign banks operating in China on a cross sectional and time series basis[4]. Ratio analysis,

[3] See Berger, Hunter, and Timme (1993) and Berger and Humphrey (1997) for a detailed review of the literature on banking efficiency. Berger and Mester (2003) also provide an updated review of the banking efficiency literature.

[4] Recent ratio analysis studies on banking sector in China include Li *et al.* (2001), Shirai (2002), Shih, Zhang, and Liu (2007).

however, does not account for differences in production efficiency, output/input mix and output/input prices. It also does not capture the differences in risk taking strategy of different banks. Consequently, the results of these studies should be interpreted with caution.

To date, there are a few efficiency studies of banks in China, all of which use the BankScope database, the Almanac of China's Finance and Banking, or a combination of both, while employing different methodologies and different input and output measures. These studies examine different aspects of Chinese banking efficiency; such as ownership, foreign bank entry and foreign bank participation, in addition to examining the effects of the recent market liberalization.

Berger, Hasan, and Zhou (2009) use stochastic frontier analysis and the translog functional form to compare and contrast the cost and profit efficiency of four different banking ownership groups. These are Big Four state-owned banks, non-Big Four state-owned banks, majority private domestic banks, majority foreign banks, and no majority ownership banks. Their sample includes 38 banks operating between the 1994 and 2003. The authors find that foreign banks are the most profit efficient banks, followed by private domestic banks, with state-owned banks- particularly the Big Four- being the least profit efficient. The cost efficiency measures, on the other hand, yield different rankings. Specifically, the non-Big Four state-owned, Big Four and majority foreign banks are the most efficient, while the majority private domestic banks are the least efficient. They also report that smaller banks with foreign participation are more efficient than other forms of bank ownership. The authors, however, do not provide any information regarding the efficiency change of Chinese banks through time, nor the

impact of WTO accession on the banking efficiency. Garcia-Herrero and Santabarbara (2008) also study the impact of foreign ownership of the profit and cost efficiency of Chinese banks during the period of 1999-2006. They report that foreign participation, especially foreign strategic partnership by private investors, has the largest positive effect on the efficiency of Chinese banks.

Lin and Zhang (2009) examine the profit and cost efficiency of different bank ownership groups in China. Using data between 1997 and 2002, they conclude that "Big Four" state owned banks in China are less profitable, less cost efficient, and have a lower asset quality compared with other groups of bank ownership.

Shujie, Feng, and Willenbockel (2007) similarly study the performance of Chinese banking using a stochastic frontier approach. Their sample includes 22 banks, consisting of the Big Four state-owned banks, joint-stock owned banks, and city commercial banks for the years 1995-2001. They report that, on average, non-state-owned banks outperform state-owned banks by 8 to18 percent depending on the definition of outputs used. In addition, they provide evidence that banks that are subject to a hard budget are more efficient than those banks that experience a soft budget and are as a result more capitalized by state funds.

Fu and Heffernan (2005) also employ stochastic frontier analysis to study the cost efficiency of state-owned and joint-stock-owned banks over the period of 1985-2002. Their findings indicate that joint-stock banks are relatively more efficient than state banks under three disturbance distribution assumptions; half-normal, exponential, and truncated-normal. Furthermore, they find that, on a time series basis, the efficiency gap

between the two groups is wider during the two reform stages of 1985-1992 and 1993-2002.

Kumbhakar and Wang (2005) use the same frontier methodology and similarly report that the Big Four banks are less efficient than joint-equity banks and that deregulation of the mid 1990s did not result in significant bank efficiency improvement in China.

Chen, Skully, and Brown (2005) employ a non parametric technique to examine the change in the efficiency of Chinese banks between 1993 and 2000 in response to the 1995 banking deregulation. Their sample consists of 43 banks which are categorized in four groups; Big Four banks, joint-equity banks operating nationwide, joint-equity banks operating regionally, and investment banks. They report that the efficiency of banks has declined from 1997 to the end of study period or the year 2000, indicating that the 1995 banking deregulation has had a positive impact on banking efficiency only in the first year of its implementation. Concerning the comparative efficiency of different ownership groups, they report that large state banks have a relatively higher mean efficiency score compared to the other ownership types considered.

To sum, there exists a limited number of studies examining Chinese banking efficiency, and they yield mixed findings. In the present paper, we use a non parametric technique to compare and contrast the cost efficiency of domestic banks (and their subgroups; Big-Four state-owned, joint-stock, and city commercial banks) with foreign banks operating in China. We contribute to the existing literature on several fronts. First, we use a more comprehensive, larger, and recent data set to capture the efficiency dynamics of the recent developments in the Chinese banking industry between 1998 and

2006. Second, we investigate Chinese banking efficiency and technological progress (and their components) over the sample period by comparing the efficiency indices of banks before and after joining the WTO. Third, we provide evidence on the potential determinants of Chinese banking efficiency using Tobit regression models. Finally, the paper explores the productivity growth (and its components) of Chinese banks through time and their response to the WTO accession. To the best of our knowledge, the last three issues are not addressed in the existing literature.

3. Recent Developments in the Chinese Banking Environment[5]

Before the 1978 open door policy, the Chinese banking system consisted of only one bank, the People's Bank of China (PBC), which acted as a central bank, a banking regulatory and supervisory agency, and a commercial bank at the same time. During this era, the functions of the banking system were confined to collecting revenues and distributing funds to state-owned enterprises based on the central government budgetary priority plan. The monopolistic position of PBC was ended in 1978 when banking activities and responsibilities were stripped from PBC and given to four newly established specialized banks known as the "Big Four": the rural banking activities of PBC were transferred to the Agricultural Bank of China (ABC); the foreign currency transaction banking activities of PBC were assigned to Bank of China (BOC); the banking activities related to the construction sector were delegated to China Construction Bank (CCB), and finally the Industrial and Commercial and Bank of China (ICBC) took

[5] This section is drawn mostly from Berger, Hasan, and Zhou, (2009) and Shirai (2002). For detailed information on the history of banking development in China, please refer to the above papers.

banking responsibilities related to commercial and industrial activities[6]. These banks were involved in providing credit to government-designated "priority sectors" rather than acting on a commercial basis. Because the activities of each specialized bank was limited to a specific sector and in order to encourage competition in the banking market, the PBC granted in 1985 the Big Four the right to expand their activities to different sectors of the economy.

The deterioration of the asset quality of the Big Four banks, evidenced from the accumulation of a huge volume of NPLs, induced a new banking legislation in 1993. Two actions were undertaken. First, three brand new policy banks were created – China Development Bank, Agricultural Development Bank of China, and Export-Import Bank of China. The idea was to free the Big Four from "government-directed policy lending activities" and to allow them to compete on a commercial basis. Second, to enhance the financial position of these banks and to qualify them for possible Initial Public Offering (IPO) listing and strategic partnership with foreign banks, the central government established four asset management companies to acquire the NPLs of these banks[7]. Later on, in 2003, the regulatory and supervisory responsibilities of PBC were transferred to a newly created government agency, China Banking Regulatory Commission (CBRC).

Parallel to the above restructurings, there have been other equally important reforms that contributed to a change of banking structures in China. The establishment of

[6] Three of the four big state owned banks, China Construction Bank, Bank of China, and Industrial and Commercial Bank of China have already gone public. CCB raised US$ 9.2 billion in October 2005 and BOC raised a total of US$ 11.18 billion through IPO listings in Hong Kong (June 2006) and Shanghai (July 2006). In November 2006, ICBC raised US$22 billion through an IPO with dual listing in Hong Kong and Shanghai stock markets. As announced by the Chairman of the China Banking Regulatory Commission, the last of Big Four, ABC, may get a huge cash injection and go public some time in 2007 (China Daily December 27, 2006).

[7] PBC claims that these steps have caused a drop in NPL for three out of the Big Four banks, namely BOC, CCB, and ICBC, from an average of 32 to 4.19, 3.51, and 4.10 percent of assets respectively (China Daily, December 27, 2006).

joint-equity banks during this period contributed significantly to more competition in the banking industry. These banks are owned by private enterprises and operate at a regional or national level, and presently there are 12 of them operating in China[8]. In 1996, the small urban credit unions were required by the PBC to merge and transfer to city commercial banks. Currently there are about 112 city commercial banks that are owned by individuals, local enterprises and local governments and their activities are restricted to the local markets[9].

Penetration of foreign banks in the Chinese banking market started in the late 1970s when PBC allowed foreign banks to open representative offices in the country. From this time until China's accession to the WTO in 2001, the activities of foreign banks were very limited. For instance, restrictions were imposed in terms of geographic expansion, minimum acceptable level and currency denomination of deposits, currency denomination in granting loans, and ownership of local banks. After WTO accession and especially as of 2003, the CBRC took steps to promote foreign ownership of domestic bank through strategic partnerships. It allowed locally incorporated foreign banks to engage in all foreign and domestic currency business without quota limitations, whereas foreign bank branches can only conduct foreign and domestic business with corporate

[8] Joint-stock commercial banks are either wholly or partially privately owned banks that have licenses to operate nationally. At the end of 2006, there were 12 joint-stock commercial banks comprising 15 percent of total banking assets. The average NPL of these institutions at the end of 2006 was 2.8 percent, with capital adequacy ratio of 8.15 percent.

[9] City commercial banks represent a small segment of the Chinese banking sector. At end of 2006 total assets of these institutions was around RMB 2.6 trillion (USA 346 billion), accounting for only six percent of total banking assets. City commercial banks often maintain a close tie with their respective city government, which holds a 75 percent share of the banks, and about 70 percent of their loans are granted to state and city owned enterprises that operate within the city boundaries. Recently, the CBRC announced the criteria for city commercial banks to expand their geographic operations and ownership structure. In April 2006, Bank of Shanghai was the first city bank to be allowed to operate a branch outside its home town in Ningbo. Since then, eight city commercial banks have received permission for cross-city geographic expansion. In July and August 2007 and for the first time, three city commercial banks decided to go public and since then, at least seven more city commercial banks have decided to follow suit.

and institutional clients only. Such deregulation resulted in a wave of strategic partnerships of foreign banks with local banks[10]. While the asset (foreign currency loan) share of foreign banks in China at the end of 2001 was about 1.5 (15%) percent, reached a minimum of 1.36 (7.4%) percent at the end of 2003, and started increasing since then. Foreign investors bring in good corporate governance mechanisms, the latest innovations in communications technology, and better risk management skills. It is expected that strategic foreign ownership will improve the efficiency of the banking sector in China. One of the objectives of this study is to test whether such efficiency benefits have effectively materialized in Chinese banking in general and for foreign banks in particular.

4. Data and Methodology

4.1 Data

The major source of the data for this study is Thompson's BankScope, covering a period of nine years from 1998 to 2006. In the case of missing or questionable values, we refer to the original financial information provided by the bank's annual financial report. We categorize Chinese banks based on their ownership organizational structure into domestic (and its sub-groups; Big-Four state owned, joint-stock, and city commercial) and foreign banks. Every attempt has been made to include as many banks in our sample as possible[11]. We only include banks that are in operation for the entire period under the study, or those which started operations after 1998 and continued until the end of the year

[10] One example is the Citigroup partnership with Guangdong Development bank, in which Citigroup owns 20 percent stake, as do China Life, State Grid, and CITIC Trust. IBM holds 4.74 percent stake, and Guangdong Financial Investment Holding will hold 0.85 percent stake (China Business Matrix December 6, 2006).

[11] We exclude non-commercial banking institutions such as policy-lending institutions, finance companies, and investment banks to avoid comparison problems among different types of financial institutions that may be characterized by different objective functions or technologies.

2006[12]. Because of the entry of new banks in the market during the period under study and due to missing data, our sample is an unbalanced panel data consisting of 349 observations with complete financial data for 62 banks. We believe our sample reasonably represents the total Chinese banking population in terms of the number of banks and their total assets.

We use the intermediation approach to define bank inputs and outputs. We assume that banks are financial intermediaries that accumulate deposits and purchased funds to intermediate them to borrowers. We adopt the inputs and outputs definitions used in the recent efficiency studies on Chinese banks with some modifications. In our analysis, banks employ two inputs - borrowed funds (X_1) and other inputs (labor and fixed assets, X_2) - to produce net loans (Y_1), deposits (Y_2), and other earning assets (Y_3)[13]. The price of borrowed funds (P_1) is calculated as the ratio of interest expenses to X_1, and the price of other inputs (P_2) is computed as the ratio of the sum of non-interest expenses and other operating expenses to total assets[14]. Finally, total cost (TC) is measured as sum of interest expenses, non-interest expenses, and other operating expenses.

Table 1 provides the means of outputs, inputs, input prices, total assets, and total

[12] This resulted in dropping banks whose operations were ceased due to a merger with other banks during the period under study.

[13] Berger, Hasan,, and Zhou (2009) use the same definition of inputs and outputs.

[14] Chinese banks' financial statements do not separately report expenses on salaries and benefits, expenses on fixed assets, and - in most of cases - the number of employees. To overcome this deficiency, researchers have taken different approaches in defining fixed assets and labor and their prices. For example, Berger, Hasan, and Zhou, (2009) and Chen, Skully, and Brown (2005) have used the ratio of non-interest expense to fixed assets as a proxy for the cost of fixed assets, while the cost of labor is ignored. We think that employee expenses are one of the major costs of intermediation in banking, especially in China where most banks, particularly the state-owned banks, are suffering from over employment. At the same time, we believe that the cost of labor and fixed capital should be approximated by the unit cost per dollar of total assets rather than per dollar of fixed assets. To overcome this problem, we assume that the cost of fixed assets and labor are reported in the non-interest expense items, and therefore we define the cost of fixed assets and labor as the ratio non-interest expenses (sum of other operating expenses and non-operating expenses) to total assets.

cost for all banks included in the sample, as well as for different ownership categories. The difference in the average size of banks measured by total assets is evident from Table 1. Domestic banks are much larger than foreign banks, and among domestic banks, the Big Four are the largest, followed by joint-stock banks, with city commercial banks being the smallest banks in the data set.

[Table 1 about here]

4.2 Efficiency Indices

In order to assess the efficiency of Chinese banks between 1998 and 2006, we estimate several efficiency indices by employing a non-parametric methodology proposed by Farrell (1957) and expanded by Färe, Grosskopf, and Lovell (1985). The major advantage of this approach is that the researcher is not required to presuppose any functional form for underlying technologies and to impose any assumption on the distribution of the error term. In addition, this approach can be used to model multi-input and multi-output technologies and it rules out the presence of multi-collinearity among input and output variables. We briefly explain this methodology here because it has been discussed in details in the literature of measuring banking efficiency (see for example Elyassiani and Mehdian, 1992; Aly, Grabowski, Pasurka, and Rangan, 1990; and Forsund, Lovell and Schimdt, 1980).

In the framework of this approach, given inputs, outputs , input prices, and total cost data, a number of linear programs are designed and solved to construct a host of linear best practice frontiers relative to which a set of efficiency indices are computed for each bank. The main efficiency index that belongs to this set is overall efficiency (OE),

which is measured as the ratio of the minimum potential total cost to the total observed cost.

The OE index is then decomposed into two efficiency indices: allocative efficiency (AE) and overall technical efficiency (OTE). OTE determines over-utilization inputs relative to a best practice frontier that exhibits restrictive constant returns to scale (CRS) property. AE evaluates the extent to which a bank misallocates resources i.e. utilizes input mix inconsistent with the cost minimization principle.

The OTE is further decomposed into two more indices: pure technical efficiency (PTE) and scale efficiency (SE). PTE is determined by comparing the actual inputs employed by a bank relative to a best practice frontier that exhibits constant returns to scale (CRS), increasing returns to scale, and decreasing returns to scale properties. SE is calculated as the ratio of OTE to PTE and it measures the extent to which a bank deviates from operating at the optimal scale of operation.

Let bank *k* be an observation in a sample of K Chinese banks, the efficiency indices described above can be written as:

$$
\begin{aligned}
&OE_k = OTE_k \times AE_k \\
&OTE_k = PTE_k \times SE_k \\
&OE_k = PTE_k \times SE_k \times AE_k \\
&where \\
&AE_k = \frac{OE_k}{OTE_k} \;\; and \;\; SE_k = \frac{OTE_k}{PTE_k}
\end{aligned}
\qquad (1)
$$

To compute the OE empirically for bank *k* in year *t*, we first solve the linear programming (LP) model 1 below to obtain the potential minimum total cost of production:

$$C_k^* = \min \; p \times x$$
$$subject \quad to \qquad \text{(Model 1)}$$
$$y_k \leq zY \;, x_k \geq zX \;, z \in R_+^K$$

$k = 1,\ldots..,$ K

Where C_k^* is potential minimum total cost, p is a vector of input prices, y_k is a vector (1 x n) of outputs produced by bank *k*, x_k is a vector of inputs (1 x m) utilized by bank *k*, Y is a matrix of observed outputs (K x m) produced by all banks in the sample, and X is a matrix of observed inputs (K x n) employed by all banks in the sample, and z is a (1xK) intensity vector.

The OE for bank *k* is calculated as

$$OE_k = \frac{C_k^*}{C_k},$$

where C_k^* is a defined earlier and C_k is the actual total cost incurred by bank k.

In order to estimate OTE for the k^{th} bank, we solve the following LP model:

$$\min \; \delta$$
$$subject \; to \qquad \text{(Model 2)}$$
$$s.t. \;\; y_k \leq zY, \; \delta x_k \geq zX, \; z \in R_+^K$$

Where $0 \leq \delta \leq 1$ is the OTE index for bank *k* relative to a best practice frontier that exhibits CRS. In model 2, vector *z* consists of a set of weights given to each bank included in the pooled sample by the model in construction of a common efficient frontier relative to which OTE of bank *k* is computed.

To obtain PTE, ψ , for bank k, we resolve Model 2 with $\sum_{k=1}^{K} z_k = 1$ as an additional constraint and replacing δ by ψ. The SE for bank *k* is then:

$$SE_k = \frac{OTE_k}{PTE_k} = \frac{\delta}{\psi} \qquad (2)$$

If $SE_k = 1$, ($\delta = \psi$), bank *k* is scale efficient, i.e. it lies on the frontier that exhibit CRS. If $0 \leq SE_k < 1$, then *k* is scale inefficient and an additional linear program should be solved to identify the source of scale inefficiency of this bank. More specifically, we resolve Model 2 after replacing $\sum_{k=1}^{K} z_k = 1$ by $\sum_{i=1}^{K} z_i \leq 1$ and δ by ω. The efficiency score ω measures the efficiency of bank *k* relative to a best practice frontier that displays non-increasing returns to scale property. Färe, Grosskopf and Lovell (1985) show that, if $SE_k \neq 1$ and ω = ψ, the source of scale inefficiency of bank *k* is decreasing returns to scale (DRS), or if $SE_k \neq 1$ and ω ≠ ψ, then the scale inefficiency of this bank is due to increasing returns to scale (IRS).

4.3 Determinants of Efficiency

In order to identify the potential determinants of Chinese banking sector efficiency, we follow Coelli, Rao, and Battese (1998) and employ a Tobit model to allow for the restricted (0,1) range of OE estimate which is treated as a dependent variable. This model is generally used when the dependent variable is censored and observations are clustered at a lower threshold, an upper threshold or both[15]. We classify the determinants of bank efficiency into three categories: bank-specific variables, ownership type, and macro characteristics. The first group of variables includes profitability ratios (return on equity, return on assets, net interest margin), capitalization (the ratio of equity to total assets) and bank size (total assets and bank market share). Ownership type is considered

[15] See Coelli, Rao, and Battese(1998), Grigorian and Manole (2002) and Maghyereh (2004).

with two dummy variables FB and BF to represent Foreign banks and Big Four banks respectively. Finally, macro variables are included to represent the regulatory quality and economic development in China as control variables[16]. The definitions and descriptions of the variables are listed in table 2, and we provide summary statistics of the variables used in the Appendix.

[Table 2 about here]

With respect to bank-specific variables, the empirical literature mostly reports a positive relationship between profitability and efficiency (see Mester 1996; Carbo, Gardener, and Williams 2002)[17]. The level of financial capital is also likely to affect banking efficiency. Equity is a more expensive source of funding compared to deposits, but the implications on cost efficiency are not straightforward (Berger and Mester 1997). Similarly, the relationship between bank size and cost efficiency is not settled in the literature[18]. The operations of large banks could be more cost efficient than those of small banks because the former may enjoy economies of scale and scope. Alternatively, they could be operating a large number of branches, at IRS, and or utilizing expensive technology which may lead to greater cost inefficiencies.

The second set of variables accounts for bank ownership in China, classified as either foreign or domestic Big Four. The existing literature on the comparative efficiency of foreign versus domestic banks is not conclusive. The general conclusion, however, is that foreign banks operating in developing countries are more efficient than domestic banks,

[16] Since all other variables are ratio data, and in order to reduce scale bias, the logarithm value of total assets and GDP per capita are considered.
[17] However, in the banking industry, a low cost efficient bank may not necessarily be a low profit bank. For example, a decision made by manager to employ high a quality input (such as qualified labor), and hence incur high costs, results in a higher cost (low cost efficiency) but higher revenue and higher profit in the long term.
[18] See for example Mester (1996).

but foreign banks operating in developed countries are not more efficient than domestic banks.

Finally, two additional control variables are added to the Tobit models. First, we argue that the prevailing regulatory quality may affect the efficiency of the banking sector. To capture this effect, we use one of six governance indicators developed by Kaufmann, Kraay, and Mastruzzi (2006)[19]. It ranges from -2.5 to +2.5 for the period 1998-2006 with higher values indicating better regulatory quality. It measures the ability of the Chinese government to formulate and implement sound policies and regulations that permit and promote private sector development. Hence, we hypothesize that an environment with higher regulatory quality is conducive to higher efficiency levels. Second, the level of per capita Gross Domestic Product (GDP) is included as a control variable in the Tobit regressions to capture the effect of operating environment and general economic wellbeing on OE.

4.4 Total Factor Productivity Growth

To examine the inter-temporal productivity growth of the Chinese banks between 1998 and 2006, we follow Färe Grosskopf, Norris, and Zhang (1994), and Berg, Førsund, and Jansen (1992) and compute the Malmquist index of total factor productivity for each bank in the sample. This index measures the total factor productivity change between two dates and it is the product of overall technical efficiency change and technological change. It can be written for bank *k* as:

$$M_k = \Delta OTE_k \times \Delta T_k \qquad (3)$$

[19] The six governance indices provided by Kaufmann, Kraay, and Mastruzzi (2006) include voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and corruption.

Where M_k is the Malmquist total factor productivity index quantifying the total productivity change, ΔOTE_k is the overall technical efficiency gain (loss), and ΔT_k is the technological change (progress or regress) between two dates. If M_k >1, then bank *k* has experienced productivity growth between two periods, say t and t+1. If M_k <1, then bank *k* has suffered productivity decline between the two periods.

The first term on the right hand side of (3) measures overall technical efficiency change or catching up with the best practice frontier so that $\Delta OTE_k > 1$ ($\Delta OTE_k < 1$) suggests that the relative OTE of bank *k* has increased (declined) between the two periods t and t+1. More specifically, we compute OTE for each bank in our sample in years t and t+1, and calculate the overall technical efficiency change between the two periods for bank *k* as:

$$\Delta OTE_k = \frac{OTE_k^{t+1}}{OTE_k^{t}}$$

Finally, the second term on the right hand side of equation (3) represents technological change or shift in the best practice frontier between two periods as a result of innovation which is measured based on observations from both period t+1and t. If $\Delta T_k > 1$($\Delta T_k < 1$), then bank *k* has experienced technological progress (regress) between the two periods t and t+1. In particular, we compute OTE of bank *k* in period t+1 relative to a frontier that exists in period t, $OTE_k^{t+1,t}$, then we calculate OTE of the bank in year t , $OTE_k^{t,t}$, the technological change of bank *k* is the following ratio:

$$\Delta T_k = \frac{OTE_k^{t+1,t}}{OTE_k^{t,t}}$$

5. Empirical Results

5.1 Cost Efficiency Components, 1998-2006

We solve the linear programming models outlined in the methodology section to compute the efficiency indices for each bank in our sample. Our panel dataset consists of both domestic and foreign banks operating in China over the entire 9-year sample period from 1998 to 2006. By using a pooled sample of all banks, we assume that there is a common frontier to all, implying that the technologies utilized by various bank categories are similar. Table 3 reports summary statistics of efficiency indices for domestic and foreign banks, in addition to the three ownership sub-categories of Big Four banks, Joint-Stock Banks, and City Commercial banks.

[Table 3 about here]

First, we note that the average of overall efficiency for all banks is 87.02 percent, indicating an average potential total production cost saving of 12.98 percent over a nine-year period, if all banks had been fully overall efficient[20]. Furthermore, the average cost inefficiency of banks in China over the sample period is mainly due to overall technical inefficiency (88.60 percent) while allocative inefficiency and hence suboptimal "input-mix" plays less important part in overall inefficiency.

Second, while domestic banks are slightly more overall efficient and significantly more allocatively efficient, foreign banks are found to be more overall technically, pure technically, and scale efficient. The mean value of OE of domestic banks is 0.56 percent higher than that of foreign banks, suggesting that domestic banks can produce the same output level with 0.56 percent lower total production cost than foreign banks. Also, the higher mean value of allocative efficiency for domestic banks indicates that these banks

[20] Although based on somewhat different sets of inputs and outputs, the results are consistent with those reported by Berger, Hasan, and Zhou (2009) who report overall cost efficiency of 0.897 for a sample of 38 banks operating in China between 1994 and 2003.

chose a more optimal input mix consistent with cost minimization compared to foreign banks. However, domestic banks suffer significantly from over-utilization of inputs since their OTE index is 4.84% less than foreign banks. The further breakdown of OTE into pure technical efficiency and scale efficiency shows that foreign banks operate closer to the best practice frontier that exhibits CRS and they also operate at a more optimal scale of operation over the sample period.Foreign banks' overall technical inefficiency is to some extent due to pure technical inefficiency (0.9710 for PTE versus 0.9531 for SE) since these banks operate at a more optimal scale compared to domestic banks. This, however, is not the case for domestic banks whose PTE and SE are at the same level (SE=0.9371 versus PTE=0.9374).

Examination of standard deviations of efficiency indices for all banks shows that the volatility of OE has been highest and that of AE has been lowest over the period under study for all banks. We also note that the efficiency indices of foreign banks are generally more dispersed relative to domestic banks, except for SE where the domestic banks group demonstrates notably a higher level of variability.

Third, the analysis of the efficiency indices given in Table 3 for three ownership sub-categories that constitute domestic banks suggests that the Big Four banks have been the most efficient among all the domestic bank sub-categories in terms of all efficiency indices expect for allocative efficiency. More specifically, in the case of OE, OTE, PTE, and SE the Big Four are the most efficient, whereas in the case of AE, City Commercial banks are more efficient than other domestic banks[21]. The index of overall efficiency has

[21] This anomaly is also reported by Berger, Hasan, and Zhou (2009), and for which they provide two likely explanations; the skimping hypothesis and government subsidy on the cost side. For further details, see Berger and De Young (1997).

an average of 95.25 percent for Big four group (most overall efficient) and 85.15 percent for City Commercial (least overall efficient). However, a further examination of the results reveals that the Big Four banks experienced an input mix sub-optimization as indicated by their AE level (AE=0.9871) compared to other domestic banks (0.9908 and 0.9929 for Joint-Stock and City Commercial banks respectively). Nonetheless, the Big Four remain the most technically efficient banks (OTE=0.9650 as compared to 0.8874 and 0.8574 for Joint-Stock and City Commercial banks respectively), albeit their overall technical inefficiency is caused mainly by scale inefficiency (SE=0.9730) rather than pure technical inefficiency (PTE=0.9917). On another note, the figures show that Joint-Stock banks are ranked second among domestic banks in terms of all efficiency measures except for AE where they rank first. We also note that the efficiency rankings are almost clear-cut among the three domestic banks sub-categories other than for the AE in which the Big Four have the lowest score.

It is quite interesting to note that the Big Four banks have consistently higher mean efficiency scores in terms of all indices compared with Foreign Banks. In addition, all ownership sub-categories of domestic banks stand on top of foreign banks group in terms of AE (AE of 0.9871, 0.9908 and 0.9929 for Big Four, Joint-Stock and City Commercial respectively compared to 0.9234 for Foreign Banks). The decomposition of OE into AE and OTE leads us to believe that domestic banks generally do not suffer from input mix sub-optimization as they do from input over-utilization, whereas foreign banks suffer equally from both input mix sub-optimization and inputs over-utilization. The main point of this analysis is that, in the case of resource allocation consistent with cost minimization, all domestic banks sub-categories are doing much better than the foreign

banks group.

The finding that the Big Four banks outperform foreign banks in terms of cost efficiency is opposite to the predictions that, generally, foreign banks are likely to be more efficient than their peers. In the case of Chinese banking, foreign banks clearly see growing opportunities in this market. However, they remain critical of the regulatory environment, even after WTO accession, in light of prevailing currency restrictions (where the currency is not fully convertible) and the lack of a comprehensive credit history that would otherwise allow them to enter the retail market (PricewaterhouseCoopers, 2007).[22]

Fourth, the examination of standard deviations of efficiency indices shows that, for all banks, the volatility of OE has been highest and that of AE has been lowest over the period studied. The figures of Table 3, furthermore, illustrate that the efficiency indices of foreign banks exhibit considerably more variability compared to those of domestic banks except in the case of SE where Domestic banks have a higher standard deviation. We note that among all domestic banks, the Big Four banks have the lowest standard deviations in all efficiency indices except for AE, while the results between Joint-Stock and City Commercial are mixed.

5.1 Cost Efficiency Components, Pre and Post WTO

We start by assessing whether the relative efficiency of banks in China has improved over the entire 1998-2006 period. We hypothesize that the WTO membership combined with globalization and the integration of financial institutions and markets,

[22] Further, foreign banks still suffer from foreign debt quotas above which they are subject to a 5% business tax, not to mention the lack of national treatment regarding capital requirements and limits on off-shore funding (PricewaterhouseCoopers, 2007).

generate an intensely competitive banking environment that increases the efficiency of Chinese banks over time. It follows that we expect to identify the effect of WTO accession in the form of an upward trend in the Chinese banking efficiency over the study period.

We report the mean values of annual efficiency indices for all ownership groups in Table 4, where all displayed efficiency measures are computed relative to the same common sample frontier similar to Table 3.

[Table 4 about here]

The reported efficiency indices for all Chinese banks, foreign, domestic, and domestic banks sub-categories display an irregular trend over entire sample period (almost pointing to the absence of a trend for efficiency indices). A closer look at the results in the different panels of Table 4 shows that this irregularity is mainly due to the lack of trend in the pattern of efficiency indices observed for Joint-Stock (Panel C2) and City Commercial banks (Panel C3). In contrast, a clear trend in the reported efficiency indices is identified for the Big Four banks and to a lesser extent for Foreign banks. Specifically, the Big Four banks (Panel C1) experienced a clear rising trend in cost efficiency prior to WTO accession in the year 2001, but the trend is reversed after the WTO membership date. This initial analysis seems to be in disparity with the general consensus that lower trade barriers, free trade, and competition will result in higher efficiency and performance in the economy of the member country, a major philosophy upon which WTO is built. The decline in the efficiency of Chinese banks may have been the result of restrictive banking policies that remained in place post WTO accession. While the WTO rules allowed foreign banks to conduct foreign currency business in all

parts of the country, their scope of business and geographic operations was nonetheless restricted. These artificial restrictions were phased out gradually and terminated at the end of December 2006, but the share of foreign banks in China's banking market remained at below 2 percent. [23] Despite of all of the above, the results in Panel B suggest that foreign banks have generally enjoyed a rise in their cost efficiency post WTO accession in 2001.

In order to verify the above conclusion and to analyze the impact of WTO membership on the efficiently of Chinese banks further, we divide the entire sample period (1998 to 2006) into two sub-periods: the pre-WTO membership sub-period (1998-2001) and the post-WTO membership sub-period (2002-2006). We present the mean values of all efficiency indices for both sub-periods in Table 4/a.

[Table 4/a about here]

All of the reported efficiency indices (except for PTE) are, on average, higher for all banks in the pre-WTO membership sub-period compared to the post-WTO membership sub-period. In fact, the PTE component of OTE is consistently improved for all banks operating in China post WTO accession. However, these results do not hold alike for foreign and domestic banks. In the case of foreign banks, it is interesting to note that every efficiency index is higher post-WTO membership compared to pre-WTO membership while the reverse is true for Domestic banks. It seems that foreign banks are reacting more positively than Domestic banks to the WTO accession as figures related to the domestic banks sub-categories displayed in Panels C1, C2 and C3 indicate. As can be seen from these panels, the efficiency indices are in general higher during the pre-WTO

[23] Later on, the Chinese authorities postponed the actual date implementation to April 2007, Wall Street Journal April 23, 2007, page A8.

membership sub-period relative to the post-WTO membership sub-period, with the exception of PTE for the Big Four and City commercial banks group, and of OE, AE, and PTE for the Joint-Stock banks group.

To sum, the analysis shows that the efficiency of domestic Chinese banks has weakened after China's accession to the WTO in 2001, while foreign banks have become more cost efficient in regards to all the measured efficiency indices.

5.2 Tobit Regressions

Table 5 reports the Tobit regression results for three models. Model 1 investigates the determinants of Chinese cost efficiency over the entire period under study, while Models 2 and 3 consider the pre- and post-WTO accession sub-periods separately, in line with the analysis of the previous section. In all models OE is the dependent variable.

[Table 5 about here]

The results of Model 1 show that profitability, capitalization and bank size are significant and positive determinants of the cost efficiency of Chinese banks. However, neither bank ownership type nor the institutional environment is found to be a significant determinant of overall efficiency.

In assessing the impact of WTO accession on the efficiency of Chinese banks, the figures in Models 2 and 3 provide some useful insights. When considering the 1998-2001 period, the coefficient of Foreign ownership is negative and significant, confirming the finding of the previous section. Prior to WTO accession, foreign banks were significantly less cost efficient than their peers. The insignificance of other coefficients in Model 2 may not be surprising since the banking system in China was mostly dominated by large

state-owned banks prior to 2002. The primary objective of these banks is not, and has never been profit maximization or better capitalization. Chinese bankers generally have difficulty assessing the financial health of private companies because of poor reporting standards and the lack of independent ratings. For that reason, they still prefer to lend to state-owned enterprises which have the implicit guarantee of the government. In any case, foreign banks are found to be significantly less cost efficient than domestic banks. This may be due to the fact that the Big Four state-owned banks in China carry much larger nonperforming loans (NPLs) than foreign owned banks, which in turn overestimates the amount of loans reported by domestic banks compared to foreign banks for a given amount of inputs[24].

On the other hand, the results reported for Model 3 show that the bank efficiency results in the post-WTO period are the main drivers for the findings of Model 1. Here again, each of profitability, capitalization and bank size are found to be significantly positively related to the cost efficiency of Chinese banks. In addition, after China gained accession to the WTO, foreign banks' presence was significantly positively reflected on their cost efficiency levels. The positive and highly significant sign on Foreign in Model 3 confirms the finding of the previous section that foreign banks have enjoyed an increase in their cost efficiency levels after China joined the WTO. In contrast, we do not find that the Big Four banks are significantly more cost efficient than their peers. There is a public misconception in China that depositors' savings held by large state-owned banks, especially the Big Four banks, carry implicit guarantees by the government. Through

[24] For example, the NPL ratio of the Big Four state-owned banks in 2006 declined to 9.22 percent from 10.49 percent compared to previous year. At the same time, the NPL ratio of Joint-stock Banks fell to 2.81 percent from 4.22 percent relative to a year earlier (CBRC website). A similar discrepancy between the NPLs of the Big Four and Joint-Stock Banks prevails throughout the period of this study.

their extensive nationwide branch networks, the Big Four state-owned banks are able to attract the majority of savings of the public, thereby increasing their interest expenses and putting an upward pressure on their cost efficiency, especially given their high NPL levels[25].

Finally, the institutional environment is not found to be a significant determinant of cost efficiency levels in China. Measures of governance other than the regulatory quality are included in the regression, but the insignificant results nonetheless hold[26]. Such a result may seem anomalous, but the lack of good governance practices and sound accounting standards prevailing in the industry have been the rule for a long time, and we expect that it will be a while before change sees its way through to positively affect cost efficiency.

5.3 Efficiency Change, Technical Progress and Productivity Growth

Table 6 shows the mean values of the technical efficiency change, technological change and the Malmquist total factor productivity index for all banks as well as for different ownership groups over the 1998-2006 period. We note that $\Delta OTE>1$, $\Delta T>1$, and $M>1$ indicate an improvement in overall technical efficiency, technological progress, and productivity growth respectively. As can be observed from the figures reported in Table 6, total factor productivity of all Chinese banks included in the sample has dropped by 7.87% between 1998 and 2006 (M=0.9213). This decrease is mainly caused by technological regress (5.20%), whereas overall technical efficiency contributed to a

[25] We distributed a questionnaire among Chinese business major students and asked their opinion if their parents' deposits with major banks carry implicit government guarantee. They unanimously responded positively. They also backed their response by referring to the recent cash infusion by government into three of the four big state-owned banks to reduce their NPLs.

[26] The additional Tobit regression results are available from the authors upon request.

minor decline of 2.82% in this drop. The total factor productivity of both Foreign and Domestic banks has deteriorated over the sample period. Foreign banks have experienced a decline of 6.01% in total factor productivity due to both technological regress and decrease in overall technical efficiency. Similarly, the total factor productivity of Domestic banks has fallen by 7.68% over 1998-2006, caused by a 5.63% technological regress and 2.17% overall technical efficiency decline.

[Table 6 about here]

The figures reported in table 6 also illustrate that, for the sub-categories of domestic banks, only Joint-Stock banks have demonstrated a 0.23% increase in total factor productivity, caused exclusively by an increase in their overall technical efficiency (1.02%) since these banks faced a technological regress (of 1.72%) during the period under study. The Big Four have experienced a decline in total factor productivity of 2.39% caused by technological regress (1.89%) and overall technical efficiency change (0.51%). City Commercial banks, the last sub-category of domestic banks, have suffered a significant reduction in total factor productivity of 11.81% as a result of technological regress of total of 8.15% and overall technical efficiency decline of 4.75%. These results are in contrast with the findings reported by Matthews, Guo, and Zhang (2009) who also examine the productivity growth of 14 nationwide Chinese banks, four state-owned "Big Four" banks, and ten joint-stock commercial banks over the period 1997-2006.[27] The authors report productivity growth for the five largest joint-stock banks, and a decline in productivity for the "Big Four" and smaller joint-stock banks. They also provide

[27] To the best of our knowledge, Matthews, Guo, and Zhang (2009) is the only published paper that examines the productivity of Chinese banks using Malmquist index.

evidence to indicate that the productivity increase and decrease is due to technical progress/ regress rather than to efficiency change.

In order to investigate the effects of Chinese WTO membership on the total factor productivity of banks operating in China, a pre and post analysis can be inferred using Tables 6/a and 6/b respectively.[28] Table 6/a summarizes the comprehensive decomposition of the mean values of the total factor productivity index for all Chinese banks, foreign and domestic banks, including the sub-categories of domestic banks during the pre-WTO membership sub-period (1998 to 2001). Similar results for the post-WTO membership sub-period (2002-2006) are presented in Table 6/b. These tables also contain the related components of total factor productivity, i.e. technological change (progress or regress) and change in overall technical efficiency (increase or decrease). We hypothesize that membership in the WTO creates a more competitive banking environment in China that brings about more efficient banking operations and technological advancement. The results show that total factor productivity increased for all Chinese banks by 12.44% from 90.94% in the pre WTO membership to 103.38% in the post WTO membership. While total factor productivity has increased for both foreign banks and domestic banks, it has improved more for domestic banks than for their foreign counterparts (11.27% versus 13.07% for Foreign and Domestic banks respectively). Furthermore, we note that the increase in the total factor productivity for both groups is caused by technological progress and overall technical efficiency improvement.

[Table 6/a about here]

[28] We are grateful for an anonymous referee for pointing our attention that the results of Table 6/b might be interpreted by the reader as opposing to those of Table 4/a. Please note that Table 4/a presents *average efficiency levels* for each period (pre- and post-WTO), whereas shows the change in OTE *within* the post-WTO period.

[Table 6/b about here]

The analysis of the total factor productively of domestic banks sub-categories reveals that, except for the Big Four sub-group, which suffered a little decline of 1.75%, all banks have enjoyed increase in their factor productivity. In addition, according to the figures of Tables 6/a and 6/b and by comparing the pre and post-WTO membership sub-periods, all domestic banks sub-categories have enjoyed technological progress ranging from 1.48% (City Commercial Banks) to 4.67% (Joint-Stock banks), except for the Big Four banks that suffered a technological regress of 1.01% between the two periods. Moreover, Big Four banks have experienced a 0.76% drop in their overall technical efficiency while both Joint-Stock banks and City Commercial banks sub-categories have benefited from a rise in overall technical efficiency. In sum, these results provide evidence to suggest that the Chinese banks have in general enjoyed total factor productivity growth following admission to WTO.

6. Summary and Conclusions

For the past two decades, the banking sector in China has undergone major structural reforms to increase the competitiveness of the Chinese banks. The major strategy so far has been partial privatization of banks by selling IPO shares on exchanges and forming strategic partnerships with foreign banks. Attempts also have been made to improve management quality, credit control processes and risk management techniques, in order to reduce the accumulation of bad loans on the books of state-run banks. China's accession to WTO in 2001 and its commitment to fully open its banking sector to foreign competitions by December 2006 led to further reforms in recent years. The study of

banking efficiency in China is of timely importance as foreign banks seek more access to the world's most populous nation. In parallel, domestic Chinese banks face the challenge of expanding regionally across borders[29]. It is without any doubt that such strategic moves (both inside and outside China) are more likely to be successful if attention is maintained on achieving high efficiency levels.

This paper examines the impact of recent banking reforms on the cost efficiency of the Chinese banking sector, which comprises foreign and domestic banks, with the latter including three sub-categories: Big Four state-owned, Joint-Stock banks and City Commercial banks. The study also compares the efficiency and productivity growth of different bank ownership groups prior to and after China joined WTO. We further identify the potential determinants of the cost efficiency of Chinese banks.

The findings of the study provide evidence that over the period under study, domestic banks were, on average, more overall efficient than foreign banks, and they exhibited less variability in efficiency levels. Among domestic banks, the state-owned Big Four are the most efficient followed by Joint-Stock and City Commercial banks. Foreign banks, in contrast, are more overall technically, pure technically, and scale efficient than domestic banks. Furthermore, we find that while the Big Four banks experienced a clear rising trend in their cost efficiency prior to WTO accession, Foreign banks have enjoyed a rise in their cost efficiency post WTO accession in 2001. Despite remaining restrictions on the scope and geographic operations on foreign banks in China post WTO accession, the greater competitive environment induced from opening the

[29] To illustrate, the state-owned Industrial and Commercial Bank of China recently purchased a more than 50% stake in a bank in Indonesia, a country where foreign investors are allowed to own up to 99% in domestic banks (WSJ, December 12, 2006).

market is translated into positive efficiency gains for foreign banks. The results of the Tobit regressions also confirm that, while the overall cost efficiency of Foreign banks was significantly lower than for domestic banks prior to WTO accession, this trend is reversed after 2001. The analysis of the Malmquist index shows that total factor productivity has increased for both foreign banks and domestic banks over the period under study, caused by both technological progress and overall technical efficiency improvement. These results provide evidence to suggest that the Chinese banks have in general enjoyed total factor productivity growth following admission to WTO.

In the light of the above results, we can draw the following policy implications. First, since foreign banks are in a position to improve cost efficiency in China post WTO accession, there is mutual benefit in strategic partnerships between foreign banks and domestic Chinese banks. Therefore, the current strategy of promoting domestic banks partnership with foreign banks is in the right direction, allowing foreign banks to access the Chinese domestic retail banking market. Chinese banks, in return, will benefit from valuable risk management skills, information technology and general bank management know-how. In particular, Chinese bankers need to obtain risk assessment skills in order to reverse the past and continuing rising trend in bad loans. Under such circumstances, regulators should make every attempt to improve the rule of law in the country and better provide protection to both depositors and creditors, as this move will also improve banking efficiency. Furthermore, the foreign partnership of Chinese banks with foreign banks should not be confined only to the larger Chinese banks since the medium size stock-equity and smaller city banks with lower efficiency but with good retail customer

basis are good candidates for mutually beneficial foreign partnerships[30][31]

Second, the investigation of the determinants of cost efficiency in Chinese banking indicates that, prior to WTO accession when most lending in China was directed toward non-lucrative state-owned enterprises; profitability was not a significant determinant of cost efficiency. However, as China meets its commitments to the WTO to embrace more competition and openness, the banking sector expands its lending base to the private sector to meet the demand of growing economy, private ownership of banks increases, and foreign institutions' strategic investments in Chinese banks also rise. Our findings indicate that the greater quest for more profitability in the industry is improving banking efficiency and will have positive effects on the economy as a whole because investments will be targeted to most productive uses.

Finally, we find that larger banks are more cost efficient than smaller banks, and that only smaller city banks are suffering from productivity decline. While the Big Four banks dominate the banking sector, there are about 120 smaller banks in China which carry a large volume of NPLs and operate in different regions of China. It follows that it is harder and costly for regulators to monitor and control the activities of these banks even though they are generally confined to operate in a certain region. On the other hand, these smaller banks have a strong retail customer base with access to regional deposits and mid-market loans. To improve the regional competitive pressure and enhance efficiency of these banks, it is recommended that regulatory authorities promote

[30] The latest example is Citigroup partnership with Guangdong Development bank, please refer to footnote 8.

[31] Kodjo (2007) study the comparative advantages of Chinese local joint-stock banks with that of Big Four and small city banks as recipients of foreign investment and concludes that strategic partnerships between foreign banks and Chinese joint-stock banks are mutually beneficial.

the consolidation of these banks with better performing local banks. Alternatively, there is also a good opportunity for foreign banks to acquire majority ownership of these small banks to boost their regional presence in China.

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Table 1: Means of the Outputs, Inputs, and Price of Inputs, 1998-2006 (USD million)

A. All Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	26	31	35	36	46	51	57	33	34
Y1	32971.65	29439.99	27493.67	29736.78	27271.48	29180.88	28295.72	48356.00	53970.24
Y2	46806.99	43739.64	44460.13	47271.99	42770.22	44495.63	45095.87	80421.00	90714.11
Y3	15438.99	15367.68	18647.99	18893.91	17263.94	17811.16	18745.35	34865.00	41591.95
X1	50092.36	47221.53	47657.03	50486.82	45506.25	48199.83	48809.52	88298.00	99705.46
X2	713.84	545.00	499.91	543.22	499.99	493.93	485.77	722.00	1029.95
P1	0.0384	0.0322	0.0280	0.0242	0.0159	0.0162	0.0169	0.0183	0.0205
P2	0.0143	0.0145	0.0135	0.0131	0.0132	0.0125	0.0134	0.0101	0.0103
TA	53146.66	49858.75	50312.91	53070.42	47538.85	50289.54	49185.56	92264.45	105307.18

B. Foreign Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	6	6	5	7	8	8	8	3	4
Y1	502.18	626.90	1254.08	1516.03	1834.15	2540.20	3256.20	10360.85	10705.54
Y2	831.48	1111.33	2115.00	1937.99	2393.80	3423.83	4643.76	18299.45	17836.83
Y3	456.70	614.17	1144.44	884.84	1255.86	1574.43	2186.28	9945.78	9802.37
X1	909.68	1207.92	2298.40	2306.70	3005.30	4081.60	5331.73	20096.23	20262.11
X2	18.24	21.82	27.19	23.49	30.66	24.72	32.98	107.81	260.02
P1	0.0319	0.0461	0.0463	0.0367	0.0180	0.0105	0.0098	0.0181	0.0244
P2	0.0140	0.0138	0.0141	0.0158	0.0198	0.0174	0.0181	0.0115	0.0108
TA	1033.13	1333.67	2499.12	2473.84	3170.69	4264.84	5562.74	20704.34	20892.65

C. Domestic Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	20	25	30	29	38	43	49	30	30
Y1	42712.50	36355.13	31866.94	36548.68	32626.70	34137.29	32383.80	52155.25	59738.87
Y2	60599.64	53970.43	51517.66	58214.68	51270.52	52136.89	51700.30	86633.39	100431.07
Y3	19933.68	18908.52	21565.25	23240.92	20634.07	20831.94	21448.88	37357.18	45830.56
X1	64847.16	58264.80	55216.81	62116.50	54453.82	56407.87	55907.93	95117.86	110297.91
X2	922.52	670.56	578.70	668.67	598.80	581.22	559.69	782.99	1132.60
P1	0.0403	0.0289	0.0249	0.0212	0.0154	0.0172	0.0180	0.0183	0.0200
P2	0.0144	0.0147	0.0135	0.0124	0.0118	0.0115	0.0126	0.0100	0.0103
TA	68780.72	61504.76	58281.87	65283.38	56879.52	58852.27	56307.66	99420.46	116562.44

C1. Big Four	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	4	4	4	4	4	4	4	4	4
Y1	192,851.10	201,236.13	204,647.90	221,957.30	251,355.35	284,815.43	297,281.28	328820.50	370187.20
Y2	266,715.65	295,263.70	330,920.78	356,760.70	395,005.58	440,028.75	489,614.83	557035.93	637372.65
Y3	81,427.50	94,602.10	131,547.50	136,005.73	153,506.15	172,088.83	198,118.65	241636.50	293501.90
X1	284,540.65	312,503.68	346,879.15	371,739.13	412,961.08	469,486.63	519,330.18	613420.34	701861.02
X2	3,888.73	3,460.53	3,505.18	3,947.60	4,554.18	4,813.83	4,712.83	5044.80	6451.25
P1	0.0418	0.0322	0.0275	0.0202	0.0138	0.0120	0.0119	0.0138	0.0161
P2	0.0132	0.0108	0.0102	0.0104	0.0107	0.0097	0.0091	0.0092	0.0096
TA	301,513.48	329,750.85	366,372.75	391,457.20	432,815.23	491,349.65	518,508.23	641949.70	743002.05

C2. Joint Stock Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	8	9	9	9	10	9	10	6	6
Y1	8,063.86	9,273.06	12,177.90	16,114.37	19,410.48	29,996.70	32,217.44	32525.02	40812.96
Y2	13,501.04	13,806.23	18,439.93	23,809.80	29,907.41	42,797.04	45,155.46	47435.48	59483.40
Y3	6,503.20	7,583.57	9,985.08	11,921.56	13,028.02	17,477.13	19,105.25	17908.97	23380.85
X1	14,950.46	17,695.12	23,181.82	29,191.04	33,437.82	48,456.91	51,789.32	49986.86	62773.53
X2	282.11	217.34	264.53	330.92	366.66	498.18	686.8400	371.39	996.66
P1	0.0303	0.0233	0.0179	0.0168	0.0128	0.0139	0.0144	0.0160	0.0181
P2	0.0134	0.0128	0.0112	0.0106	0.01008	0.0096	0.0122	0.0078	0.0079
TA	15,822.49	18,542.86	24,163.62	30,313.69	34,351.69	49,894.24	53,502.71	51696.80	65579.58

C3. City Commercial Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
Observations	8	12	17	16	24	30	35	20	20
Y1	2,291.83	1,706.36	1,636.21	1,690.83	1,678.69	1,955.72	2157.33	2711.26	3326.98
Y2	4,640.24	3,662.48	3,287.48	2,930.93	2,882.65	3,219.93	3522.88	4312.26	5327.06
Y3	2,617.24	2,171.04	1,817.75	1,416.87	1,657.91	1,670.80	1927.65	2335.78	3031.21
X1	4,897.11	3,945.77	3,550.07	3,231.42	3,459.27	3,715.99	4122.14	4996.66	6242.60
X2	78.83	80.49	56.44	38.92	36.29	41.79	48.72	54.12	109.66
P1	0.0497	0.032	0.0281	0.0238	0.0168	0.0189	0.0198	0.0199	0.0213
P2	0.0161	0.0174	0.0154	0.0139	0.0128	0.0124	0.0131	0.0109	0.0111
TA	5,372.56	4,310.83	3,852.51	3,410.38	3,610.16	3,873.36	4286.15	5231.71	6569.38

Y1 = Net Loans
Y2 = Total Deposits
Y3 = Total Other Earning Assets
X1 = Loanable Funds
X2 = Other Inputs
P1 = Unit price of Loanable Funds
P2 = Unit price of Other Inputs
TA = Total Assets

Table 2: Description and Definition of Tobit Model Variables

Variable Name	Description
Profitability	Return on assets, return on equity and net interest margin. Source: authors' calculations based on data from BankScope
Capitalization	The ratio of bank equity capital to total assets. Source: authors' calculations based on data from BankScope
Size	The natural logarithm of total assets, and the market share in assets and deposits of each bank. Source: authors' calculations based on data from BankScope
Foreign	A dummy variable for foreign-owned banks in China.
Big Four	A dummy variable for the Big Four banks in China.
Regulatory Quality	An indicator of the regulatory quality in China. The index is one of six governance indicators. It ranges from -2.5 to +2.5 for the period 1998-2006 with higher values indicating better regulatory quality. It measures the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Source: Kaufmann, Kraay, and Mastruzzi (2006).
Economic Development	Logarithm of per capita GDP expressed in constant 1995 US dollars for the period 1996-2006. Source: World Bank Indicators

Table 3: Descriptive statistics of efficiency measures per ownership group relative to a pooled sample (common) frontier, for the sample period 1998-2006
Tests of differences in means/ variance are conducted between efficiency scores of **Big Four** and **Foreign banks**. [(a)] indicates larger mean scores significant at the 1% level; [(b)] indicates larger variance significant at the 1% level.

Mean:

	All Banks	Foreign	Domestic	Big four	Joint-stock	City commercial
OE	0.8702	0.8655	0.8711	0.9525[a]	0.8792	0.8515
AE	0.9809	0.9234	0.9917	0.9871[a]	0.9908	0.9929
OTE	0.8860	0.9267	0.8783	0.9650[a]	0.8874	0.8574
PTE	0.9399	0.9531	0.9374	0.9917[a]	0.9503	0.9213
SE	0.9424	0.9710	0.9371	0.9730[a]	0.9338	0.9314

Standard Deviation:

	All Banks	Foreign	Domestic	Big four	Joint-stock	City commercial
OE	0.1125	0.1788[b]	0.0956	0.0353	0.0971	0.0944
AE	0.0591	0.1327[b]	0.0129	0.0193	0.0116	0.0116
OTE	0.0996	0.1112[b]	0.0955	0.0312	0.0980	0.0930
PTE	0.0693	0.0966[b]	0.0628	0.0172	0.0560	0.0641
SE	0.0763	0.0417[b]	0.0801	0.0233	0.0860	0.0832

Minimum:

	All Banks	Foreign	Domestic	Big four	Joint-stock	City commercial
OE	0.3000	0.3000	0.5900	0.8400	0.5900	0.5900
AE	0.4688	0.4688	0.9000	0.9000	0.9394	0.9333
OTE	0.6000	0.6000	0.6000	0.8600	0.6100	0.6000
PTE	0.6300	0.6300	0.6500	0.9100	0.6500	0.6800
SE	0.6500	0.8367	0.6500	0.8878	0.6632	0.6500

Maximum:

	All Banks	Foreign	Domestic	Big four	Joint-stock	City commercial
OE	1.0000	1.0000	1.0000	1.0000	0.9900	1.0000
AE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
OTE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
PTE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SE	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 4: Means of efficiency measures per year/ownership groups relative to a pooled sample (common) frontier.

OE = Overall Efficiency; AE = Allocative Efficiency; OTE = Overall Technical Efficiency; PTE = Pure Technical Efficiency; SE = Scale Efficiency; N = Number of Observations.

A. All Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9373	0.9158	0.9343	0.8944	0.8657	0.8896	0.8698	0.9452	0.9224
AE	0.9717	0.9751	0.9791	0.9768	0.9697	0.9826	0.9536	0.9797	0.9835
OTE	0.9654	0.9384	0.9537	0.9147	0.8922	0.9063	0.9128	0.9645	0.9382
PTE	0.9742	0.9703	0.9611	0.9592	0.9491	0.9622	0.9672	0.9879	0.9841
SE	0.9908	0.9674	0.9923	0.9541	0.9392	0.9416	0.9435	0.9762	0.9534
N	26	31	35	36	46	51	57	33	34

B. Foreign Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9367	0.9250	0.9740	0.8571	0.9250	0.9325	0.9663	0.9833	0.9500
AE	0.9450	0.9713	0.9780	0.9271	0.9636	0.9419	0.9724	0.9900	1.0000
OTE	0.9917	0.9517	0.9960	0.9200	0.9600	0.9900	0.9938	0.9933	0.9500
PTE	0.9967	0.9967	1.0000	0.9586	1.0000	1.0000	1.0000	0.9967	0.9975
SE	0.9950	0.9549	0.9960	0.9590	0.9600	0.9900	0.9938	0.9966	0.9523
N	6	6	5	7	8	8	8	3	4

C. Domestic Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9375	0.9136	0.9277	0.9034	0.8532	0.8816	0.8541	0.9413	0.9187
AE	0.9797	0.9760	0.9793	0.9887	0.9710	0.9902	0.9506	0.9787	0.9813
OTE	0.9575	0.9352	0.9467	0.9134	0.8779	0.8907	0.8996	0.9617	0.9367
PTE	0.9675	0.9640	0.9547	0.9593	0.9384	0.9551	0.9618	0.9870	0.9823
SE	0.9895	0.9704	0.9917	0.9529	0.9348	0.9326	0.9353	0.9741	0.9535
N	20	25	30	29	38	43	49	30	30

C1. Big Four	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9625	0.9650	0.9725	0.9800	0.9775	0.9650	0.9600	0.9450	0.9200
AE	0.9724	0.9748	0.9749	0.9899	0.9848	0.9749	0.9649	0.9918	0.9346
OTE	0.9900	0.9900	0.9975	0.9900	0.9925	0.9900	0.9950	0.9525	0.9850
PTE	1.0000	0.9975	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SE	0.9900	0.9924	0.9975	0.9900	0.9925	0.9900	0.9950	0.9525	0.9850
N	4	4	4	4	4	4	4	4	4

C2. Joint – Stock Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9163	0.8811	0.9011	0.8822	0.8770	0.8978	0.8520	0.9633	0.9567
AE	0.9697	0.9645	0.9620	0.9846	0.9839	0.9825	0.9563	0.9771	0.9912
OTE	0.9463	0.9122	0.9367	0.8956	0.8920	0.9144	0.8900	0.9850	0.9650
PTE	0.9625	0.9644	0.9533	0.9689	0.9560	0.9833	0.9810	1.0000	0.9917
SE	0.9826	0.9471	0.9828	0.9244	0.9297	0.9293	0.9076	0.9850	0.9729
N	8	9	9	9	10	9	10	6	6

C3. City Commercial Banks	1998	1999	2000	2001	2002	2003	2004	2005	2006
OE	0.9463	0.9208	0.9312	0.8963	0.8225	0.8657	0.8426	0.9340	0.9070
AE	0.9933	0.9850	0.9895	0.9908	0.9633	0.9946	0.9473	0.9766	0.9876
OTE	0.9525	0.9342	0.9400	0.9044	0.8529	0.8703	0.8914	0.9565	0.9185
PTE	0.9563	0.9525	0.9447	0.9438	0.9208	0.9407	0.9520	0.9805	0.9760
SE	0.9962	0.9805	0.9951	0.9596	0.9273	0.9259	0.9364	0.9752	0.9414
N	8	12	17	16	24	30	35	20	20

Table 4/a: Means of efficiency measures for pre-WTO (1998-2001) and post-WTO (2002-2006) accession relative to a pooled sample (common) frontier across all ownership
OE = Overall Efficiency; AE = Allocative Efficiency; OTE = Overall Technical Efficiency; PTE = Pure Technical Efficiency; SE = Scale Efficiency; N = Number of Observations.

All Banks	Pre-WTO	Post-WTO
OE	0.9192	0.8929
AE	0.9760	0.9722
OTE	0.9414	0.9186
PTE	0.9655	0.9680
SE	0.9752	0.9486
N	128	221

B. Foreign Banks	Pre-WTO	Post-WTO
OE	0.9183	0.9465
AE	0.9532	0.9675
OTE	0.9617	0.9784
PTE	0.9863	0.9994
SE	0.9747	0.9790
N	24	31

C. Domestic Banks	Pre-WTO	Post-WTO
OE	0.9194	0.8841
AE	0.9812	0.9729
OTE	0.9367	0.9089
PTE	0.9607	0.9628
SE	0.9753	0.9436
N	104	190

C1. Big Four	Pre-WTO	Post-WTO
OE	0.9700	0.9535
AE	0.9780	0.9702
OTE	0.9919	0.9830
PTE	0.9994	1.0000
SE	0.9925	0.9830
N	16	20

C2. Joint-Stock Banks	Pre-WTO	Post-WTO
OE	0.8946	0.8998
AE	0.9702	0.9769
OTE	0.9220	0.9207
PTE	0.9623	0.9798
SE	0.9585	0.9386
N	35	41

C3. City Commercial Banks	Pre-WTO	Post-WTO
OE	0.9206	0.8684
AE	0.9894	0.9721
OTE	0.9298	0.8936
PTE	0.9479	0.9517
SE	0.9812	0.9391
N	53	129

Table 5: Tobit Regression Results

Results from Tobit censored regression models to investigate cost efficiency determinants of Chinese banks. In all models, the dependent variable is Overall Efficiency (OE), and the independent variables are profitability, capitalization, bank size, Foreign and Big Four dummy variables, regulatory quality, and economic development. Profitability is measured by return on assets. Capitalization is calculated as the ratio of equity to assets. Size is proxied by the natural logarithm of total assets. Big Four and Foreign are dummy variables for the domestic Big Four and Foreign banks respectively. Regulatory quality measures the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Economic development is the natural logarithm of per capita GDP.

Variable	Model 1: 1998-2006	Model 2: 1996-2001	Model 3: 2002-2006
Profitability	2.4015	1.6736	3.5282
	(1.3039)**	(2.3472)	(1.4825)***
Capitalization	0.1899	0.0294	0.1883
	(0.0716)***	(0.1360)	(0.0781)***
Size	0.0221	0.0069	0.0232
	(0.0045)***	(0.0099)	(0.0045)***
Foreign	0.0120	-0.0820	0.0640
	(0.0221)	(0.0433)*	(0.0239)***
Big Four	0.0033	0.0453	0.0062
	(0.0278)	(0.0542)	(0.0294)
Regulatory Quality	0.0532	-0.0380	0.2538
	(0.0343)	(0.1344)	(0.2154)
Economic Development	0.0000	-0.0002	-0.0001
	(0.00002)**	(0.0003)	(0.00001)

Standard errors are given in parentheses.
*, **, and *** correspond to 10, 5 and 1% significance respectively

Table 6: Overall Technical Efficiency Change, Technological Progress and Productivity Growth; 1998 – 2006

	ΔOTE	ΔT	M
All Banks	0.9718	0.948	0.9213
Foreign Banks	0.958	0.9811	0.9399
Domestic Banks	0.9783	0.9437	0.9232
Big Four	0.9949	0.9811	0.9761
Joint-Stock Banks	1.0198	0.9828	1.0023
City Commercial Banks	0.9525	0.9185	0.8819

ΔOTE = Overall Technical Efficiency change
ΔT = Technological Change
M = Malmquist Index of Productivity Change

Table 6/a: Overall Technical Efficiency Change, Technological Progress and Productivity Growth; 1998 – 2001

	ΔOTE	ΔT	M
All Banks	0.9475	0.9598	0.9094
Foreign Banks	0.9277	0.951	0.8822
Domestic Banks	0.9539	0.9631	0.9187
Big Four	1	0.9899	0.9899
Joint-Stock Banks	0.9464	0.956	0.9048
City Commercial Banks	0.9495	0.961	0.9125

ΔOTE = Overall Technical Efficiency change
ΔT = Technological Change
M = Malmquist Index of Productivity Change

Table 6/b: Overall Technical Efficiency Change, Technological Progress and Productivity Growth; 2002 – 2006

	ΔOTE	ΔT	M
All Banks	1.0516	0.9831	1.0338
Foreign Banks	0.9896	1.0053	0.9948
Domestic Banks	1.067	0.9835	1.0494
Big Four	0.9924	0.9798	0.9724
Joint-Stock Banks	1.0818	1.0027	1.0847
City Commercial Banks	1.0769	0.9758	1.0508

ΔOTE = Overall Technical Efficiency change
ΔT = Technological Change
M = Malmquist Index of Productivity Change

Appendix
Summary Statistics of Variables used in the Tobit Model

Variable	Mean	Std. Dev.	Min	Max
Overall efficiency	0.8702	0.1129	0.3000	1.0000
Return on Assets	0.0052	0.0052	-0.0088	0.0321
Equity to Assets	0.0729	0.1237	0.0001	0.8708
Ln(Total Assets)	8.6940	2.2562	3.7658	13.7764
Foreign Bank	0.1590	0.3662	0	1
Big Four	0.1040	0.3058	0	1
Regulatory Quality	-0.2826	0.196008	-0.56	0.09
GDP pc	1273.85	364.49	833.84	2025.00